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ABSTRACT

Recommendations for an alternative plan, based on typological analysis techniques, for the evaluation of student characteristics related to media, presentation design, and academic performance are presented. Difficulties with present evaluation plans are discussed, and different methods of typological analysis are described. Included are suggestions for preliminary implementation of these procedures in the leadership course developed for the United States Naval Academy by the Westinghouse Learning Corporation. EM 010 418 through EM 010 447 and EM 010 451 through EM 010 512 are related documents with EM 010 418, EM 010 419, and EM 010 484 being the final report. (Author/RH)

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Difficulty with present evaluation plans are discussed, and different methods of typological analysis are described. Included are suggestions for preliminary implementation of these procedures in the USNA Leadership Course research program.

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TABLE OF CONTENTS

		Page
I.	Introduction	1
	A. Difficulties of Regression Analysis. . . .	1
	B. Advantages of Typological Approach	3
	C. Recommended Administrative Steps	6
II.	Problems in Typological Analysis	8
	A. Alternative Methods	8
	B. Measures of Similarity	10
	C. Evaluation of Reliability	10
	D. Request for Proposal	11
	References	13

I. Introduction

As presently planned, the evaluation of student characteristics related to media, presentation design, and academic performance is unlikely to bring much return in terms of replicable or generalizable results. There are a number of factors leading to such a conclusion, as will be detailed below. It is the purpose of this technical paper to present an alternative plan for the study of student characteristics designed to remedy many of the difficulties involved, and in addition to provide the Naval Academy with valuable by-products in the form of generally useful information about the nature of the midshipman population.

A. Difficulties of Regression Analysis

The Naval Academy student body is, without question, a highly selected and unusual group in relation to the general population of college males. Scores of the midshipman population. undoubtedly come from relatively restricted portions of the scale on many tests of aptitude, achievement, interest, and personality. As is well known (Lord and Novick, 1968), such restricted samples will tend to show little or no relationship between variables which may be highly correlated in the general population. Thus it will be likely that few useful relationships will be demonstrated involving those variables for which the distribution of midshipman scores differ substantially from the general population. Nor is it likely that relationships demonstrated between the remaining variables are characteristic

of the general population. Although there are methods available designed to correct statistically for some of these effects, all are based upon precarious assumptions and are difficult to apply and interpret correctly. The difficulties are further compounded by the large number of independent variables which are to be investigated, and which should be taken into account in any attempt at statistical correction. Statistical corrections are therefore not a satisfactory general solution to the problems produced by biased sampling. To summarize, the conclusions regarding correlational findings must be closely limited to the midshipman population.

Even disregarding the question of generality, the large number of independent variables to be investigated and the small samples to be used in measuring the dependent variables raise serious doubts as to the reliability of findings even in relation to the midshipman population. With a large number of variables, a sizable number of significant relationships can be expected to occur by chance at the standard level of significance. Furthermore, many of the subject variables will prove to be multiple-regression techniques to discover those variables which contribute to a prediction battery but show little or no first order correlation with the criterion measures. With the additional variability associated with the use of a small sample, many variables which should show strong first-order correlations and/or contributions to a prediction battery will remain

undiscovered through lack of power. Thus, the likelihood of cross-validating these results in further experimentation is relatively low.

Ordinarily, it is recommended that correlational studies be conducted with a sample size which exceeds considerably the number of variables to be investigated. One means of limiting the number of variables commensurate with the sample sizes contemplated might be to restrict attention to variables where strong relationship can be expected on an a priori basis. However, this strategy would result in a serious loss of information about valuable but unanticipated relationships. A second possible approach is to reduce the number of variables through factor analysis. This would be feasible since independent variable data will be available on the entire midshipman population, but in view of the variety of factorial domains included in the battery the number of factors remaining after analysis may still be expected to be large. Both procedures are invalidated, as well, by the fact that the experimental subjects will not be a random or representative sample of the midshipman population, so that results based on this sample cannot be expected to hold in that population.

B. Advantages of Typological Approach

The alternative plan of attack to be presented below is designed to capitalize on the sources of difficulty inherent in the situation as described above, and to turn these disadvantages into advantages. If carried out as described, the results of this plan will not only permit a relatively direct, reliable

and meaningful evaluation of the relationships of subject characteristics as a built-in feature of future experimental designs, but also provide the Academy with a detailed and organized description of the midshipman population which can prove to be of exceptional general value for administrative, predictive, counseling, and further experimental purposes.

When samples are small and potentially biased, the usual method of studying individual difference variables and their interactions with experimental variables is to divide the subjects into groups or strata which are relatively homogeneous in terms of the individual difference variable and to employ these groups as levels of an orthogonal factor in the experimental design. This procedure serves to increase the precision of the experiment by removing variance from error into the main effect and interactions of the grouping variable, and provides results which are characteristic, at least, of those strata of the population represented in the experiment. A similar approach is suggested here, but because of the many variables involved, the stratification must be based upon an extensive preliminary analysis of the midshipman population designed to identify clusters or types of persons based on the simultaneous evaluation of the entire battery of test scores.

The fundamental premise of this approach is that the highly selected nature of the midshipman population insures that relatively few types of individuals are represented in that population. In this context, a type is defined to be a subgroup of a population, the individuals of this subgroup all having highly

similar profiles, or patterns, of scores on the entire battery of variables, but whose profiles or patterns differ considerably from those of other subgroups. Assuming that such types can be identified and described, the solution to the immediate experimental problem is very straightforward. Most of the major types of the midshipman population can be represented stratigraphically as levels in the experimental designs and differences in performance between strata can be determined, as well as interactions with other variables. The results are then directly referable to comparable types in the general as well as the midshipman population. This general method of evaluating the contribution of individual differences does not preclude additional correlational analysis where strong prior hypotheses exist, but does insure that information on unanticipated differences is obtained.

In addition, the information gained on the nature and frequency of types present in the midshipman population would clearly be of extraordinary value to the Academy in numerous applications. Such information would provide the basis for stratification in other research conducted at the Academy, and may be found useful in grouping classes, diagnosing patterns of success or failure, predicting success in future naval occupational specialties, identifying valuable types which are underrepresented in the Academy, and in many other ways which cannot be anticipated at present. In short, a midshipman typology may be a generally useful tool of personnel management, well worth the cost for these purposes even if not for the Leadership project alone. Ultimately, the

typological analysis might prove more valuable to the Academy than the Leadership Course itself.

C. Recommended Administrative Steps

Many methods for discovering classification systems and defining types have been proposed. None are definitive mathematically, and all require considerable art in application and interpretation, and are entirely beyond the competence of the average psychological investigator. Thus it is absolutely essential that the work on the typology be subcontracted to one or more prominent individuals, highly sophisticated and experienced in multivariate psychology, and particularly with previous experience in classificatory analysis. It is recommended that the following steps should be undertaken:

1. At least six months prior to the initiation of experimentation in which the results of the classification analysis are to be used, the qualified individuals (or others whom they might suggest) should be invited to submit a plan and bid for the analysis. Those to be approached should include R. B. Cattel, W. A. Gibson, L. L. McQuitty, J. H. Ward, A. C. Johnson and R. A. Shepard.
2. One or, preferably, two bids should be accepted, and data provided for analysis of the entire midshipman population for at least one class (year), and perhaps with data for random samples of all other classes (years). Results of the analysis should be evaluated and examined for agreement. If substantial

agreement among analysts exists, the classification system may be regarded as reliably established. If only one individual is given the bid, he should be required to make two or more analyses using different approaches.

3. Experimental designs should be modified to incorporate types based on the analysis. Every effort should be made to represent the major types which cover the bulk of the midshipman population.

It should not be difficult to attract advanced investigators to the problem, since situations where the data is automatically provided, and where a typology is a realistic working hypothesis and a useful goal are rather rare. At least some of these individuals should be interested in the opportunity to apply, advance, and compare experimentally their methodological approaches to the problems of classificatory analysis, while being supported financially in their effort.

In the next section is described a brief general survey of the problem of classificatory analysis, serving to point up critical areas of uncertainty and decision which must be dealt with in the proposed plans. A series of questions are suggested to be posed in the request for proposal. The worth of the results will depend critically on how these questions are handled by the investigators, and therefore will provide a basis for evaluation of the proposals.

II. Problems in Typological Analysis

Techniques of typological analysis, with few exceptions, are based on the premise that the resemblence of profiles or score patterns can be reduced to a single quantitative measure of similarity. Given a measure of similarity of each pair of persons in the sample, methods of typological analysis are applied to identify groups of persons which have high intragroup similarity and at the same time, low similarity to members of other groups. There are myriad variations of this basic approach, many of which will be indicated and briefly discussed below. A series of questions will then be suggested to be posed in the request for proposal.

A. Alternative Methods

Typological solutions of similarity measures may be based on analytic or structural methods. The analytic methods include Q-technique factor analysis (Cattel, 1952), multi-dimensional scaling (Shepard and Carrol, 1966), and latent profile analysis (Gibson, 1956) which is based upon latent structure analysis. The analytical methods employ explicit mathematical manipulations to achieve a solution.

In the case of a Q-technique factor analysis, persons are treated as tests, and using any of the common methods of factor extraction and rotation, factors are derived representing ideal types of persons. Factor loadings for an individual represent similarities to each type. The hope is to explain the similarities among people in terms of their relations to

a minimal number of ideal types, just as ordinary factor analysis explains the correlation among tests in terms of their factorial composition. The approach of the multi-dimensional scaling technique is similar, but only assumes that the similarity measures are monotonic in relation to measures of true similarity. By permitting monotonic distortion of the similarity scale, the number of dimensions required to explain the similarities can be minimized. Both factor analysis and multi-dimensional scaling recognize the existence of individuals which are intermediate between the ideal types, mixing features of two or more types.

Latent profile analysis, on the other hand, attempts to explain the correlations among tests in terms of the number of individuals which come from several subpopulations having different average (latent) profiles across tests. Intermediate individuals are not recognized, since the deviation from the group-average (ideal) profile is considered error.

Structural methods are based on various kinds of rules for grouping or clustering similar individuals and separating dissimilar individuals. The techniques are similar to those of quantitative biological taxonomy, and tend to be rather arbitrary and "artful." These methods include the computer-based "taxonome" (Cattel, et. al., 1966), simple clustering methods (Fortier and Solomon, 1966), and a whole variety of hierarchical clustering, grouping or pattern analyses (Johnson, 1967; McQuitty, 1957, 1960abc, 1961, 1963, 1964, 1966abcd, 1967; Ward, 1963). The major distinctions among these methods have to do with whether or not an overlapping hierarchy of

types is conceived, and how clusters or groups are built up or defined.

Despite their differences, it would be valuable in the present problem to be able to compare analytical and structural analyses of the same data. If some sensible relationship between the results could be established, it would provide considerable support for the existence of "real" types in the Academy population.

B. Measures of Similarity

Whether analytic or structural, the results of the analysis depend to a considerable extent on how the data is standardized and what kind of similarity measure is derived from the data. The scores may be analyzed as raw scores, standardized in relation to an external population, standardized with respect to persons in the sample, standardized over tests, or even converted to ranks (Nunnally, 1962; Kendall, 1966). Which of these should be used is not at all clear, and some rationale must be developed for selection of one over the other.

Given properly standardized data, the similarity measure may be based on the raw products, covariances, correlations (Nunnally, 1962), and may be corrected for chance association (Cattel, 1949). Invariance over variable reflection may be desired, in which case a measure of Euclidian distance (Chronbach and Gleser, 1953) or other similarity measure (Cohen, 1969) may be used having this property. Some rationale is also required for the selection of an appropriate measure.

C. Evaluation of Reliability

To assess the reliability of the findings, analysis of two

or more subgroups of the Academy population must be conducted and compared. The number of such groups, their size, and the method to be used in assessing the replicability of results is another area of uncertainty.

A second problem of reliability has to do with the assignment of individuals to a category in the taxonomic system. Clearly, if the taxonomic categories are to be used as a basis of experimental stratification, one must have some method of selecting individuals to represent the type, and also to have some assurance that they are in fact representative of that type. Further, if the typology is to be used for other descriptive or administrative purposes, the problem of intermediate or unclassifiable individuals must also be explicitly recognized and dealt with on a rational basis.

D. Request for Proposal

The following questions, based upon considerations raised above, should be posed in a request for proposal.

1. What methods of analysis or grouping rules are to be used in the derivation of the taxonomic system? What are the advantages and disadvantages of these methods in relation to other methods of achieving the same ends?

2. How are the results to be interpreted in psychological and behavioral terms?

3. How are the test scores to be standardized and used to derive measures of similarity or distance? What are the advantages and disadvantages of such measures in relation to other alternative measures?

4. How is the reliability of the findings to be assessed? What is the number and size of subgroups to be used for cross-validation of results? How is the correspondence of results between subgroups to be evaluated?

5. How is an individual to be classified into a particular category of the finished taxonomic system? What are the chances and effects of misclassification? How are intermediate or unclassifiable individuals to be handled in the system?

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